Intergal field spectroscopy survey of classical LBV stars in M33

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Summary. Five well-known LBV stars in M33 were observed with the Multi-Pupil Fiber Spectrograph (MPFS) on the 6-m Russian telescope. We observed LBVs var A, var B, var C, var 2 and var 83. In three of them, var 2, var 83, var B, large-scale nebulae were found with sizes from 15 pc and larger. The nebula shapes are complex, like one-side tails or conical nebulae. They all are related to their LBV stars. In var 2 and var 83 stars we found radial velocity gradients 15–30 km/s across their nebulae. The stars var A and var C do not show extended nebulae, but nebular lines are certainty present in their spectra.

1 Observations and data reduction

This observation were carried as continuation of our program of studing of LBV-candidate stars in M33. Here we presented results of observations on the Russian 6-m telescope with the integral field spectrograph MPFS (Afanasiev et al., 2001) in November 2004. The integral field unit of 16×16 square spatial elements covers a region of 16"×16" on the sky. Integral field spectra were taken in the spectral range 4000 – 6800 ÅÅ with a seeing from 1.0 to 1.5" (FWHM). Data reduction was made using procedures developed in IDL environment (version 6.0) by V. Afanasiev, A. Moiseev and P. Abolmasov and include all the standard steps.

2 Results and discussion

Practically all known LBV stars have circumstellar nebulae (Humphreys and Davidson 1994). Typical galactic LBV nebulae have sizes in the range of 0.1–4 pc, expansion velocities 15–100 km/s, and their dynamical times are in the range 100–$5 \cdot 10^4$ years (Weis 2003). Numerical models of the nebular expansion around massive stars (Garcia-Segura et al., 1996) have shown that those nebulae may reach diameters up to 20–40 pc at the main-sequence and pre-LBV stages.

Fabrika et al. (2005) have studied two LBV-like stars and their nebulae in M 33. The first one, B416 is a B[e]-supergiant with an expanding ring-like nebula 20×30 pc. In the second, v532 (LBV/Ofpe star) they found an

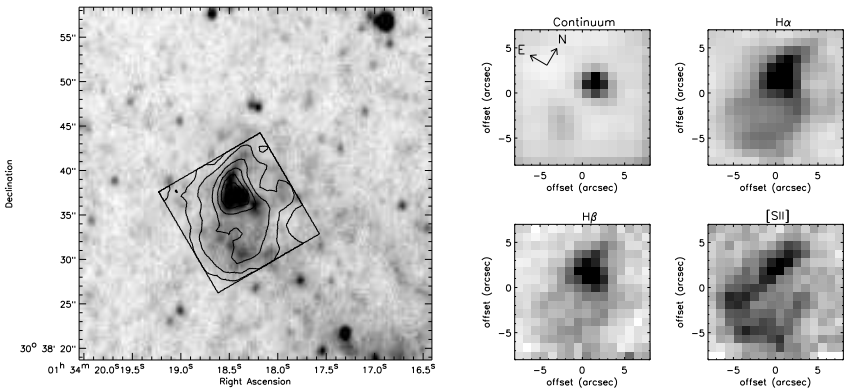

Fig. 1. Left: Hα image of the var 2 region taken by Massey et al. (2001) and the MPFS field with the line izophotes superimposed. Right: Monochromatic and continuum MPFS maps of var 2. A bipolar nebula is clearly seen in the Hα and Hβ emission line maps. It is non-symmetrical and presents different morphology in lines of different excitation. The star itself is a source of emission in permitted lines. The bipolar nebula 20x40 pc is shock excited. The Hα radial velocity gradient $\pm$30 km/s was detected along the bipolar structure.

elongated nebula. The both stars' nebulae show radial velocity gradients of about a few tens km/s. We started a special study of gas environments around classical LBV stars in M 33 to confirm a presence and to study of large-scale nebulae in these objects.

We found the large-scale nebulae around LBV stars var B, var 2, var 83. The structure of the nebulae indicates that they were formed by the LBV (or pre-LBV) winds. The nebulae are kinematically connected with the host stars. Their physical extension is about 15 – 30 pc, and their dynamical times are in the range of $10^5 - 10^6$ years. The stars var A and var C do not show extended nebulae, but nebular lines are certainty present in their spectra.

Nebulae of such dimensions around LBV-stars in our Galaxy can not be studied, because their diameters would exceed 1 degree. Detection of large-scale nebulae around LBV-stars is important, a study of these nebulae can give information about the earliest phases of evolution massive stars.

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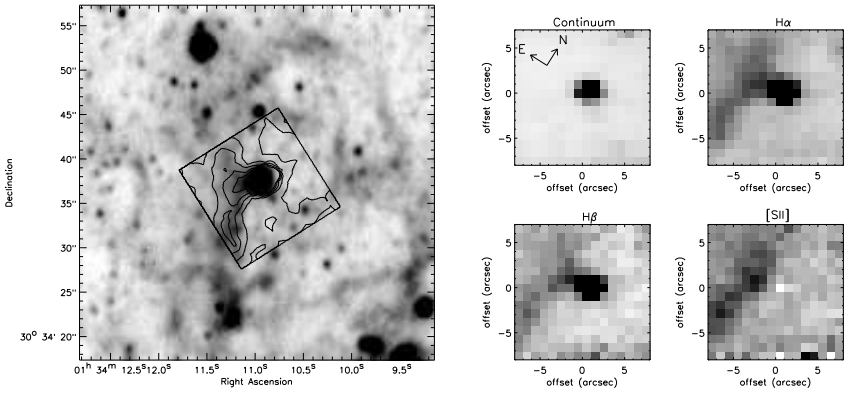

Fig. 2. Same as in Fig. 1 for var 83. In Hα, Hβ, [SII] lines we see a double-tail-like nebula, which is a part of a bigger nebula. Velocity maps in Hα show common nature of the star and the nebula. The double tail approaches us with a velocity ≈ 15 km/s.

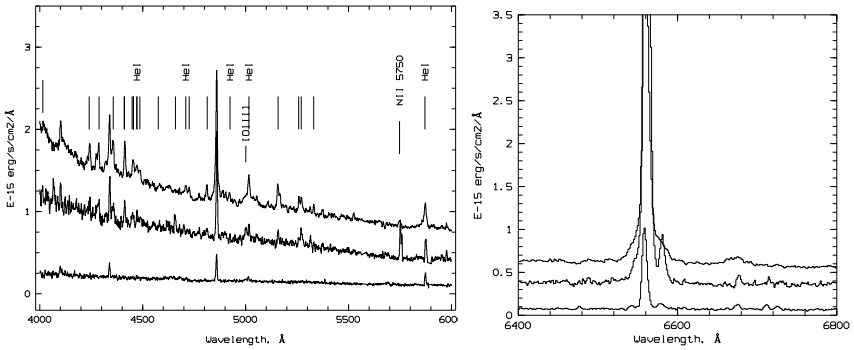

Fig. 3. Fragments of the spectra of var 2, var B, var 83 are shown from bottom to top. The brightest spectral lines are hydrogen lines and He I. Fe II, [FeII] lines shown by unlabeled vertical lines. In Hα lines we see broad components, that indicate the stellar wind.

References

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